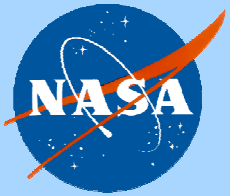

National Aeronautics and
Space Administration

**Jet Propulsion Laboratory**
California Institute of Technology
Pasadena, California

# Validating AIRS L2 cloud properties with ARM, MLS, and MODIS measurements


Brian Kahn, Annmarie Eldering, Eric Fetzer, Evan Fishbein,
Michael Garay, Jonathan Jiang, Sung-Yung Lee, et al.

California Institute of Technology

Jet Propulsion Laboratory


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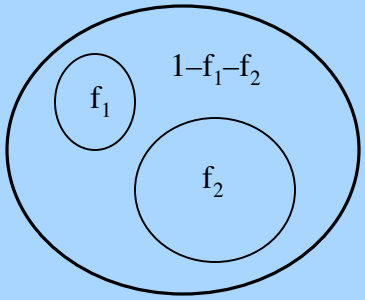
# Outline of Talk

- "Reconstruct" BT from AIRS and MODIS
- Satellite-to-surface comparisons of clouds – what can go wrong?
- Compare AIRS CTP to Manus Island ARM site ARSCL
  - Upper layer CTP
  - Both layers of CTP
- MLS-to-AIRS comparisons

# Reconstructed BT of AIRS and MODIS

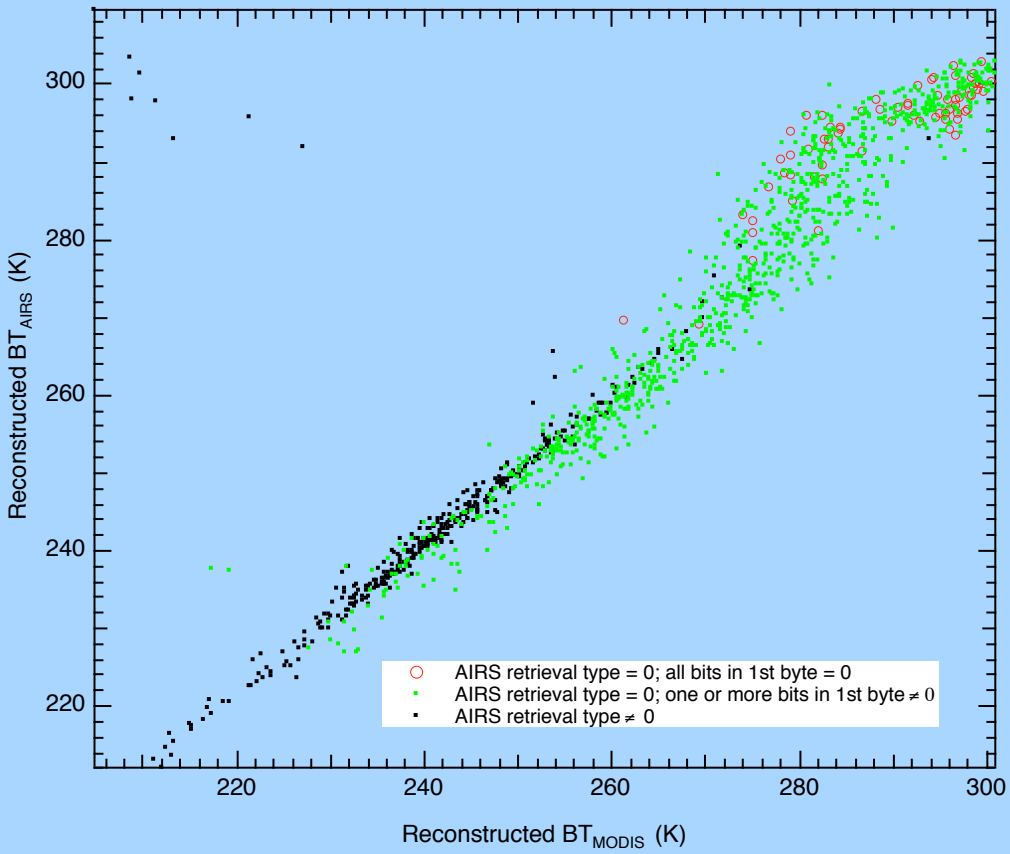
$$BT_{AIRS} = f_1 \cdot T_1 + f_2 \cdot T_2 + (1 - f_1 - f_2) \cdot T_{sfc}$$

$$BT_{MODIS} = f_{cld} \cdot T_{cld} + (1 - f_{cld}) \cdot T_{sfc}$$




- Build BT from MODIS and AIRS cloud and surface products
- This is an approximate calculation → replace Planck function by T of emitting layer or surface
- *First-order* means of comparison – it is *not* a head-to-head comparison of CTP, CTT, ECF, etc.
- All products averaged to AMSU scale

# Reconstructed BT




- Highest, optically thickest clouds agree best
- Low and optically thin clouds tend to produce more scatter
- The "kink" around 280 K may be related to MODIS retrieval method


# Comparing AIRS and ARM measurements

- ***What can go wrong? Quite a bit.***

- Vertical and horizontal cloud inhomogeneity: microphysical, optical, and bulk

  – Average ground measurements in time → "replicate" scale of satellite footprint/pixel
  – Clouds evolve: generate and dissipate with time, inhomogeneities not constant
  – Vertical and horizontal wind speed and direction shear → not constant in time & space
  – Ground measurements only sample a "line" through pixel – what about to the side?
  – Pixel not necessarily centered over ground measurement

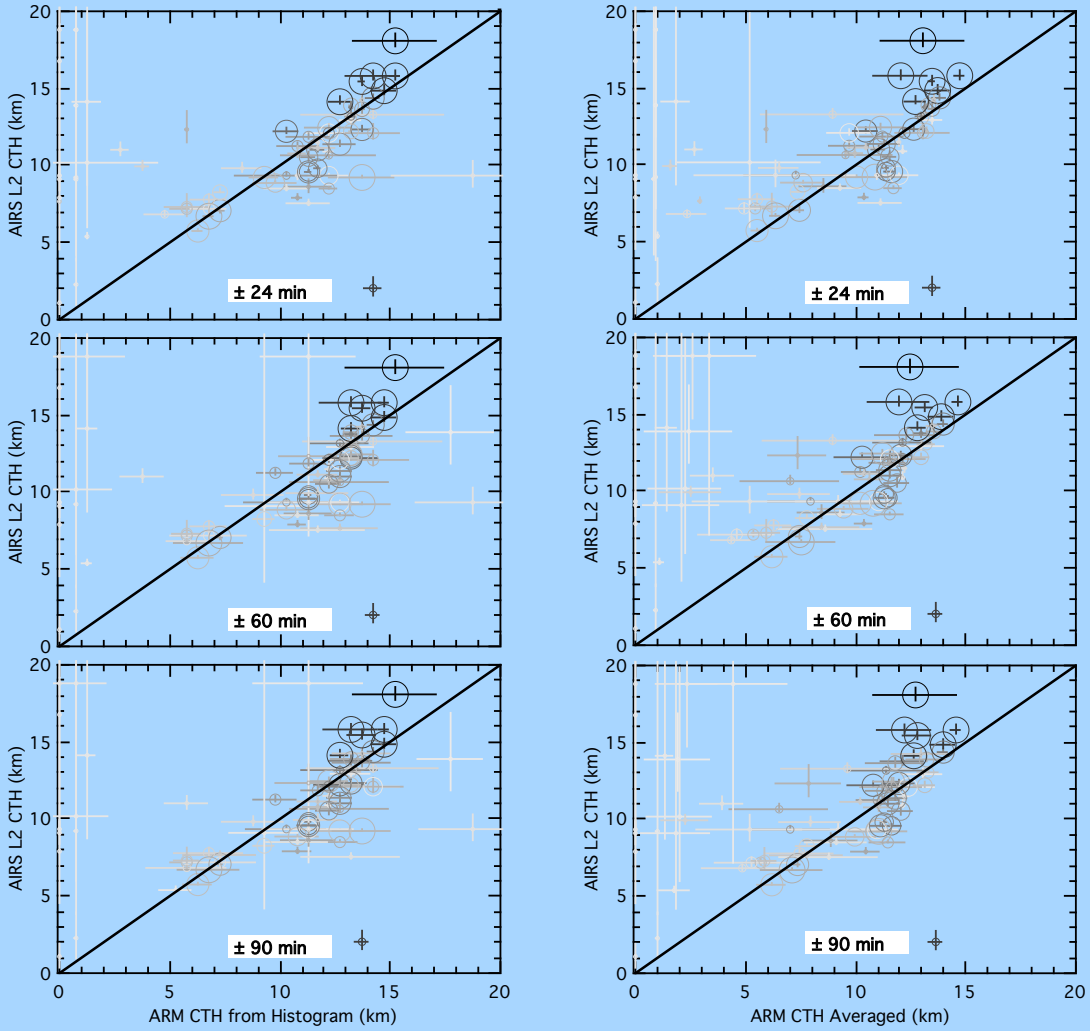

# Comparing AIRS and ARM measurements

- Passive versus active measurements → differences in sensitivities to hydrometeors

- Instrument specifics
  - Field-of-view differences, e.g., satellite view angle of AIRS ± 48.95°
  - Uncertainty in "ground truth" location of pixel
  - Uncertainties in spatial response function, not necessarily uniform over pixel

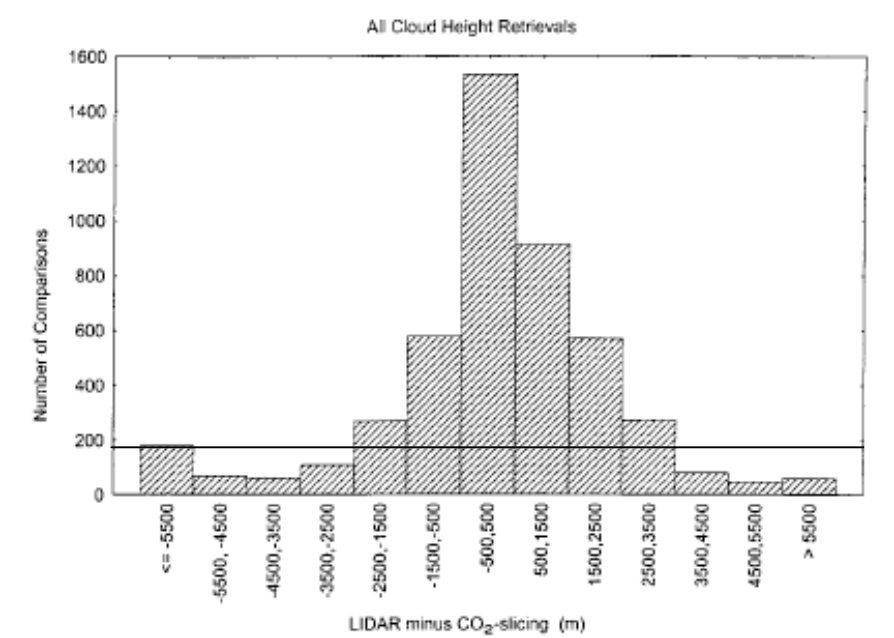
- Differences in retrieval methods
  - For identical measurements → different answers of cloud properties with different methods
  - Retrievals are ***not perfect***

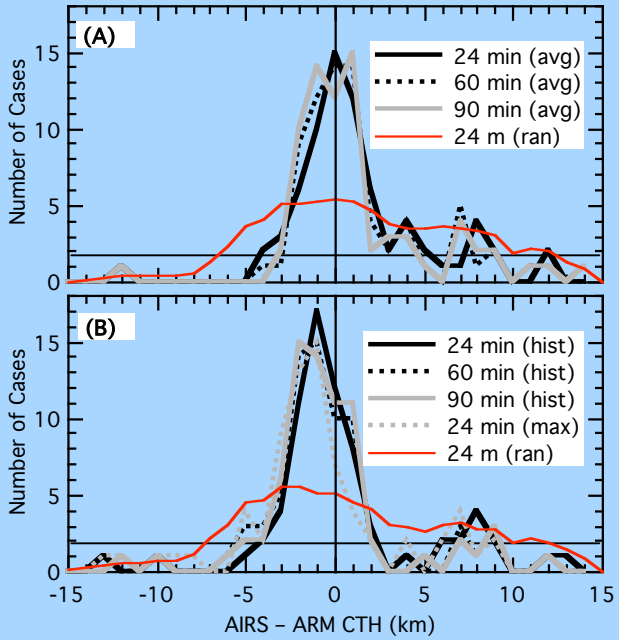
# AIRS vs. Manus Is. CTH




- Diameter of circle proportional to ECF (larger diameter, larger ECF)
- Gray scale is the BT at 960 $cm^{-1}$
- The vertical bars are L2 operational uncertainties on AIRS CTH.
- The horizontal bars are the 1–σ CTH variability for the three different time windows. These error bars are not *directly* comparable to the AIRS L2 error bars.

# AIRS vs. Manus Is. CTH

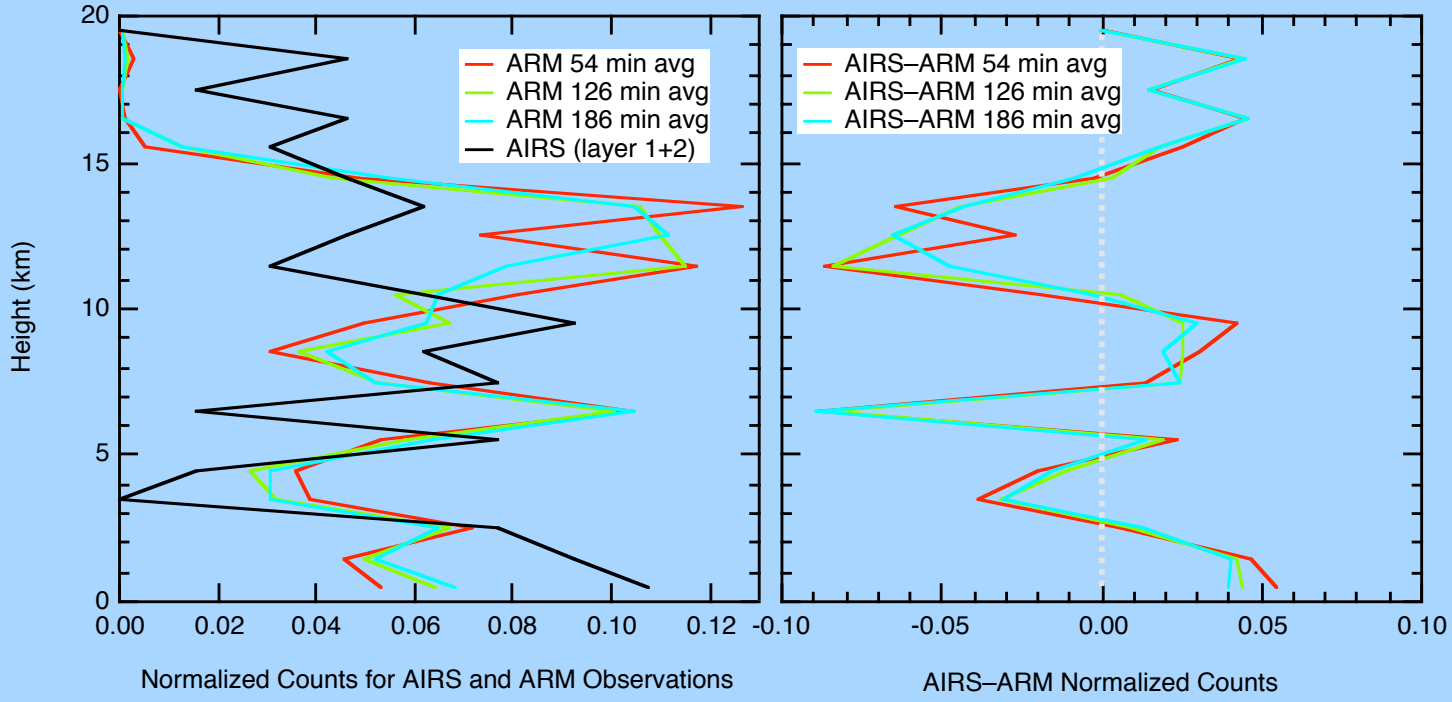



Histogram of differences for all comparisons between Cloud Lidar System (CLS) and $CO_2$-slicing of MODIS Airborne Simulator (MAS) coincident observations [*Frey et al., JGR*, 1999]

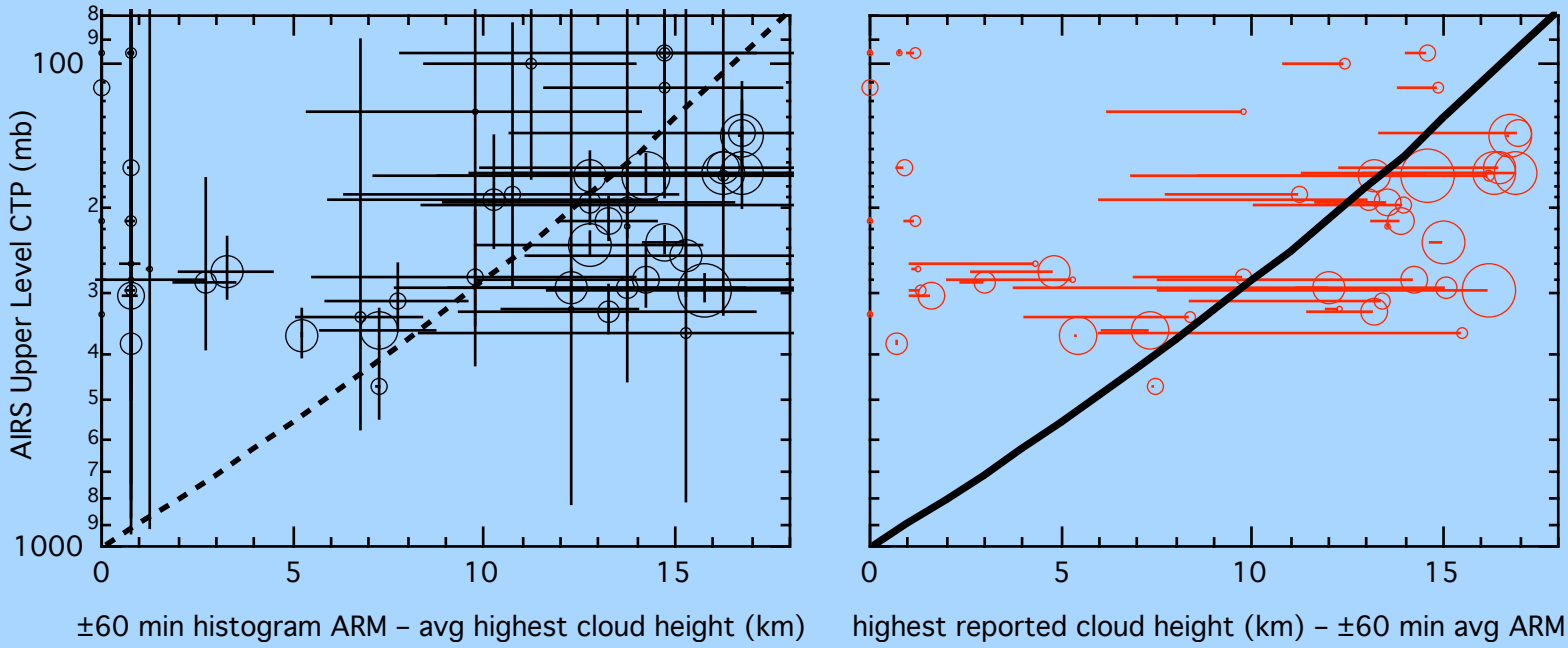
Histogram of differences between AIRS L2 CTP and ARM Manus Island ARSCL cloud boundaries. “avg” and “hist” for two definitions of ARSCL CTH, and “ran” for random, or “mixed-up” clouds

# AIRS vs. Manus Is. CTH – 2 layers




- Previous work at TWP ARM sites show three peaks ~ 1-2, 6, and 12–13 km
- AIRS indicates a peak near surface, 10km
- AIRS has a higher incidence of high cloud detection from 15–19 km

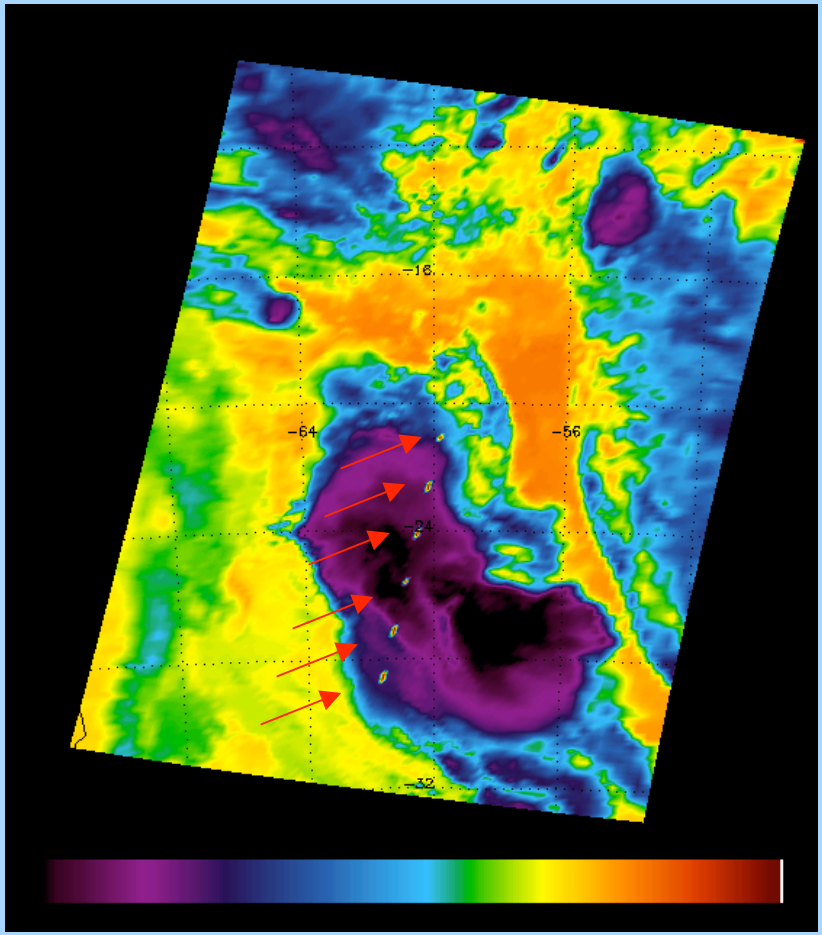
# AIRS vs. Nauru Is. CTH

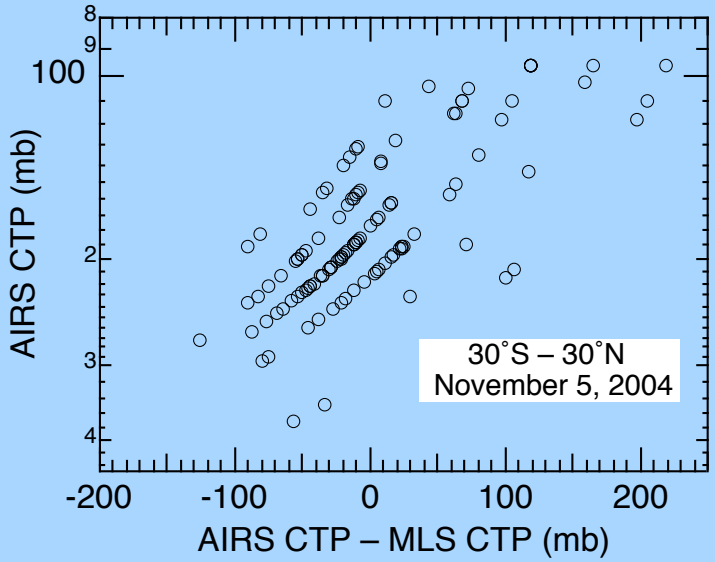



**Left**: AIRS and ARM CTH for an ECF ≤ 0.15 for 60 min histogram-derived CTH. The highest CTH peak in the histogram is used here.

**Right**: Same as the left, except the horizontal line is the difference between the *max* CTH and *avg* CTH for the ARM site.

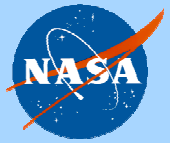
# MLS vs. AIRS CTH comparisons




| Day | MLS – AIRS CTP | MLS – high AIRS CTP |
|---|---|---|
| 11-5-2004 | –59.0 ± 83.8 mb | –10.8 ± 75.4 mb |
| 11-5-2004 | –45.3 ± 57.5 mb | –0.5 ± 67.6 mb |
| 12-23-2004 | –58.4 ± 72.9 mb | –6.7 ± 71.3 mb |

Blue: all MLS/AIRS cloudy coincidences
Red: removed AIRS ret_type = 100



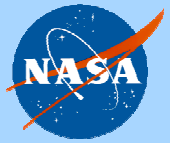


# Summary and Conclusions

- Reconstructed BT indicates best agreement for MODIS and AIRS for ret_type > 0

- Upper level AIRS L2 CTP in good agreement with Manus Is. ARSCL data
  - Use in quantitative analyses
  - Lower CTP more problematic
  - Why are the histograms of AIRS and ARM CTH so similar to Frey et al. [1999]?

- MLS – AIRS CTP comparisons encouraging
  - Best agreement for highest AIRS CTP along MLS field-of-view





# Current and future work

- Use raw backscatter lidar profiles at Manus and Nauru to validate thinnest Ci clouds
- Explore utility of ARM site surface-derived IR effective cloud fraction
- Ongoing revisions of MLS IWC – re-do analyses
- Expand to SGP, NSA ARM sites?